

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
4 December 2003 (04.12.2003)

PCT

(10) International Publication Number
WO 03/100901 A1

(51) International Patent Classification⁷: **H01M 10/38**

(21) International Application Number: PCT/KR03/01012

(22) International Filing Date: **23 May 2003** (23.05.2003)

(25) Filing Language: English

(26) Publication Language: **English**

(30) Priority Data:
10-2002-0028783 23 May 2002 (23.05.2002) KR
10-2002-0075768 2 December 2002 (02.12.2002) KR

(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, **US**, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, RO, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

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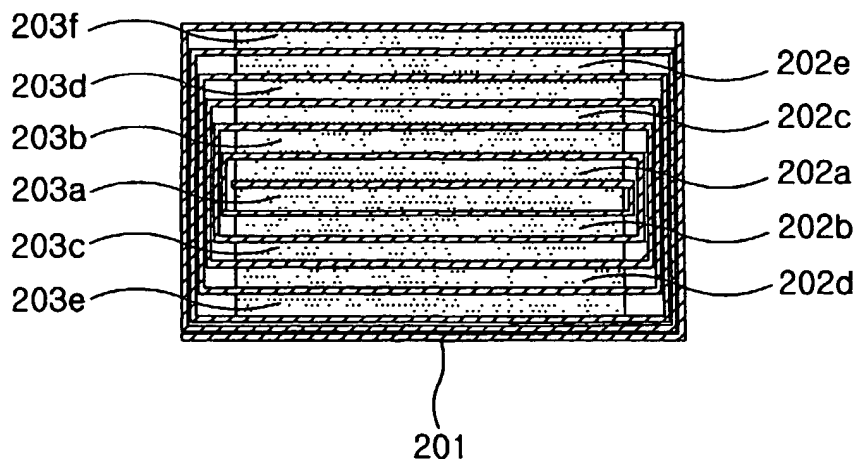
Published:

— with international search report

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: LITHIUM SECONDARY BATTERY AND ITS FABRICATION



(57) Abstract: A novel lithium secondary battery and its fabrication are disclosed. The lithium secondary battery comprises a plurality of cathode plates and a plurality of anode plates in which each of the cathode and anode plates has a tap, a separator on which an ion-conductive polymer material is coated on one side of the separator, and an electrolyte, wherein each of the cathode plates and each of the anode plates are alternating each other and connected in parallel, the taps of the cathode plates and the anode plates overlap each independently, the alternating cathode and anode plates are separated by the separator having a spiral structure obtained by successive folding in one direction or in both directions, and the electrolyte is charged between each of the cathodes and each of the anodes separated by the separator.

LITHIUM SECONDARY BATTERY AND ITS FABRICATION

TECHNICAL FIELD OF THE INVENTION

The present invention relates to a lithium secondary battery and its fabrication.

BACKGROUND OF THE INVENTION

A battery is a device to convert chemical energy of chemicals into electrical energy through electrochemical reaction, and is classified into two categories: a primary battery and a secondary battery. Among the rechargeable secondary battery, lithium secondary battery is the most important one, because it has the highest voltage and the largest energy density among existing batteries. Such lithium secondary battery is classified, according to electrolytes to be used, into three types: a liquid type battery using liquid electrolytes; a gel type battery using gel electrolytes mixed with polymer and liquid; and a solid type battery using solid electrolytes,

US Patent No. 5,460,904 discloses a method for fabricating a lithium secondary battery. The battery according to this patent is fabricated: a negative electrode membrane comprising an intercalatable material dispersed in a polymeric binder matrix is laid upon an anode collector foil in a form of an open mesh grid. A plasticized electrolyte/separator film membrane is positioned upon the negative electrode membrane and is covered with a positive electrode membrane comprising a composition of a finely divided lithium intercalation compound in a polymeric binder matrix. An aluminum collector foil or grid completes the assembly, which is then pressed between platens under heat and pressure to soften and bond the polymeric components and laminate the membrane and grid layers. The obtained laminate was then folded in zig-zag fashion to obtain a multicell battery. However, the method suffered from the disadvantages that the electrodes are connected in series and damage on the electrodes often

occurs when the laminate was folded in zig-zag fashion. In addition, the method requires addition of a plasticizer in the preparation of the plasticized separator and solvent extraction of the plasticizer. Further, short between an anode and a cathode often occurs because it is difficult to laminate uniformly in laminating process. For these reasons, the method was not popularly used in a large-scale preparation of lithium secondary battery.

US Patent No. 5,837,015 discloses a polymer battery in which a multi-layered polymer membrane was used as a separator. The multi-layered polymer membrane was obtained by coating both surfaces of the conventional electrolyte-phobic polymer membrane such as a polyethylene membrane with a polymer (for example, polyvinylidene fluoride) having an affinity for electrolytes. In the polymer battery, the conventional separator was replaced with the multi-layered polymer membrane serving as a separator. The bond of the multi-layered polymer membrane to electrodes was achieved by heating the electrodes and the multi-layered polymer membrane to a temperature sufficient to cause the gelling polymer to bond the electrodes. This technology is more improved one than the conventional method because solvent extraction is not necessary and existing facilities for manufacturing lithium ion battery can be used. But, the method suffered from the disadvantage that internal resistance of the electrochemical cell is abruptly increased, because of bad ion transports between the polymer having an affinity for electrolytes and polyethylene having an electrolyte-phobic characteristic.

KR 309,904 discloses a lithium secondary battery, comprising a separator, a plurality of cathode plates and a plurality of anode plates, wherein the cathode plates are adhered on one side of the separator in a predetermined order and a plurality of anode plates are adhered the other side of the separator such that each of the cathode plates and each of the anode plates are opposite each other, and the separator has a zig-zag form. However, the lithium secondary

battery suffers from the disadvantages that it is difficult to tightly fasten the separator, because folding of the separator is performed in zig-zag fashion. This results in a gap between the electrodes and the separator and deteriorates cycle life of an electrochemical cell. In addition, the anode plates and the cathode plates should be arranged in opposite sides of the separator such that an adhesion process is complicated. Further, because folding is performed in zig-zag fashion rather than in a fixed one-direction, the folding process is more complicated. For these reasons, this lithium secondary battery cannot be fabricated in a large scale.

SUMMARY OF THE INVENTION

Therefore, an object of the present invention is to provide a method for fabricating a lithium secondary battery with improved productivity, high yield, enhanced cycle life and enhanced charge-discharge characteristics, compared with the conventional batteries.

Another object of the present invention is to provide a lithium secondary battery having a novel structure.

Other object of the present invention is to provide a method that enables to fabricate batteries with a variety of shapes and capacities in a simple process.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of an electrode plate having a tap obtained by coating both surfaces of a current collector with a solution containing an electrode active material, and cutting the coated current collector in a suitable size.

FIGs. 2a to 2c are plan views showing preferred arrangements of a plurality of the electrode plates on one side of a separator, in accordance with the present invention.

FIG. 3 is a cross-sectional view of a stacked body obtained by a successive folding of the arrangement of FIG. 2a.

FIG. 4 is a perspective view of the stacked body of FIG. 3.

FIG. 5 is a characteristic graph showing cycle life of the battery of Example 2, compared with that of Comparative Example 1.

DETAILED DESCRIPTION OF THE INVENTION

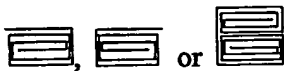
The lithium secondary battery according to the present invention comprises a plurality of cathode plates and a plurality of anode plates in which each of the cathode and anode plates has a tap, a separator on which an ion-conductive polymer material is coated on one side of the separator, and an electrolyte, wherein each of the cathode plates and each of the anode plates are alternating each other and connected in parallel, the taps of the cathode plates and the anode plates overlap each independently, the alternating cathode and anode plates are separated by the separator having a structure of , and the electrolyte is charged between each of the cathodes and each of the anodes separated by the separator. The lithium secondary battery of the present invention simplifies a folding process and an adhesion process. The battery can be prepared by folding the separator in a fixed one-direction such that folding is simplified, and the electrode plates are adhered on only one surface of the separator such that adhesion of the electrode plates to the separator is simplified, which are compared with the lithium secondary battery of KR 309,604.

FIG. 1 shows a preferred embodiment of an electrode plate having a tap used in accordance with the present invention. The electrode plate 100 (including a cathode plate and an anode plate) is prepared by coating both surfaces of a current collector 101 with a solution containing an electrode active material to form a coating layer 102 of the electrode active material, followed by cutting the coated current collector 101 in a suitable size. The electrode plate 100, but are not limited thereto, may be cut into a rectangular or circular shape, provided

that the electrode plate 100 has a tap 103. The shape of the electrode plate 100 can be changed according to the desired form of the final electrochemical cell. That is, the electrode plate 100 having a desired shape can be mass-manufactured by adjusting the template of a cutter or a puncher in a suitable shape. The electrode active material (a cathode active material and an anode active material) coated on the surface of the current collector 101 is not particularly limited. The material that has been used as an electrode active material in the filed of a lithium secondary battery can be widely used. Preferred cathode and anode active materials are exemplified in US Patent Nos. 5,837,015, 5,635,151 and 5,501,548. Specifically, a lithium transition metal oxide capable of intercalation/deintercalation of lithium ion, such as LiCoO_2 , LiMn_2O_4 , LiNiO_2 or LiMnO_2 , can be mentioned as a cathode active material. As an anode active material, a material capable of intercalation/deintercalation of lithium ion, such as lithium metal, lithium alloy, carbon and graphite, can be mentioned. Preferably, the anode active material is carbon or graphite. The cathode active material has a high electrochemical potential during intercalation/deintercalation reaction, while the anode active material has a low electrochemical potential.

The cathode or anode material is dispersed into a suitable solvent, coated onto the surface of the current collector 101, and cut into a desired size to form a cathode or anode plate, respectively. The electrode active material may be coated on one surface of the current collector. Preferably, it is coated on both surfaces of the current collector 101, as shown in FIG. 1. Double-sided coating provides an increased discharge capacity per unit volume. With regard to preferred examples of the current collector 101, please refer to US Patent Nos. 5,837,015, 5,635,151 and 5,501,548, which are incorporated herein by reference. According to the specific embodiment of the present invention, an aluminum thin plate and a copper thin plate were used as a cathode and anode current collector, respectively. Meanwhile, the electrode active material

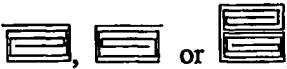
is, in general, coated on the surface of the current collector 101 in combination with a current conductive material that increases conductivity of the electrochemical cell and a binder that adheres both the electrode active material and the current conductive material to the current collector 101. The choice of the current conductive material and the binder would be readily accomplished in reference to the electrode active material that is well known to a person of ordinary skill in the art to which the present invention pertains.

The separator, which prevents a direct electrical contact of the cathode electrode with the anode electrode and provides pores for ion passage, may be any of a number of materials known in the art. Preferred examples are porous polyolefin films such as a polyethylene film or a polypropylene film, porous polyvinylidene fluoride films, porous hexapropylene fluoride films and porous polyethylene oxide films. The polyethylene film is being widely used in the art. The separator may be comprised of two or more porous films. The ion conductive polymer coated on one side of the separator fixes and binds the electrode plates to the separator, and may be any of a number of materials that exhibit electrochemical compatibility with other cell components, stability during charge/discharge reaction and an ion conductivity. As an ion conductive polymer material, polypropylene oxide, polyurethane, polymethylmethacrylate, polybutylmethacrylate, polycyanoacrylate, polyethylene acrylic acid, polyacrylonitrile, polyvinylidene fluoride, polyhexapropylene fluoride, polyethylene oxide, or mixture thereof can be mentioned. The ion conductive polymer material is dissolved into a suitable solvent, and then coated on one side of the separator by a conventional technique. As a solvent to dissolve the ion conductive polymer material, dimethyl carbonate, acetonitrile, tetrahydrofurane, acetone and methyl ethyl ketone can be mentioned. According to the preferred embodiment of the present invention, the polymer solution prepared by dissolving 0.5 to 10 parts by weight of the ion conductive polymer material into the solvent was coated in a thickness of 1 to 20 μm onto one

side of the separator. When the ion conductive polymer is used in an amount of less than 0.5 parts by weight, sufficient adhesion was not achieved. When the ion conductive polymer is used in excess of 10 parts by weight, ion mobility of the electrolyte was deteriorated.

As an electrolyte, liquid electrolyte, gel electrolyte or solid electrolyte can be used. According to the preferred embodiment of the present invention, a liquid electrolyte solution, prepared by dissolving lithium salts such as LiCF_3SO_3 , $\text{Li}(\text{CF}_3\text{SO}_2)_2$, LiPF_6 , LiBF_4 , LiClO_4 or $\text{LiN}(\text{SO}_2\text{C}_2\text{F}_5)_2$ into a polar organic solvent such as ethylene carbonate, propylene carbonate, dimethyl carbonate, diethyl carbonate and methyl ethyl carbonate, was used.

The present invention also provides a method for fabricating the lithium secondary battery, comprising:

a) coating one side of a separator with an ion-conductive polymer material; b) arranging a plurality of cathode plates and anode plates in a predetermined order on the surface of the separator on which the ion conductive polymer material is coated such that a stacked body, in which each of the cathode plates and each of the anode plates are alternating each other and connected in parallel, the taps of the cathode plates and the anode plates overlap each independently, the alternating cathode and anode plates are separated by the separator having a structure of , is prepared by a successive folding; c) performing a successive folding of the separator to obtain the stacked body; and d) housing the obtained stacked body within a package, followed by injection of an electrolyte solution and packaging.

Coating of an ion conductive polymer material onto one side of a separator is achieved by spraying or pasting onto one surface of a separator, a polymer solution in which the ion conductive polymer material is dissolved into a suitable organic solvent.

On the surface of the separator onto which the ion conductive polymer material is coated, a plurality of cathode plates and a plurality of anode plates are arranged. The order of the arrangement of the cathode plates and the anode plates are not particularly limited, provided that when successive folding was completed, a stacked body, in which each of the cathode plates and each of the anode plates are alternating each other and connected in parallel, the taps of the cathode plates and the anode plates overlap each independently, and the alternating cathode and anode plates are separated by the separator, could be obtained. Preferably, the electrode plates are arranged in an order that one anode plate (or one cathode plate) is arranged onto the end of the separator, two adjacent cathode plates and two adjacent anode plates are arranged at the middle of the separator, and empty spaces are suitably formed between the cathode plate and the anode plate.

FIGs. 2a to 2c show preferred arrangements of a plurality of the cathode and the anode plates on one side of a separator. As shown in FIGs. 2a to 2c, a plurality of cathode plates 202a to 202e (totally "202"), a plurality of anode plates 203a to 203f (totally 203) is arranged on only one side of a separator 201 and empty spaces are suitably formed between the cathode plate 202 and the anode plate 203. When successive folding, along the folding lines 204 that is formed both between the two electrode plates and between the electrode plate and the empty space, has been completed, a stacked body in which each of the cathode plates 203 and each of the anode plates 202 was alternating each other and connected in parallel, and the taps of the cathode plates 202 and the anode plates 203 overlapped each independently, could be obtained.

More specifically, Fig 2a shows an exemplary arrangement in which the cathode plates 202 and the anode plates 203 are arranged onto one side of the separator 201 in a order of an anode plate 203a/empty space/a cathode plate 202a/a cathode plate 202b/an anode plate

203b/an anode plate 203c/.../a cathode plate 202c/a cathode plate 202d/an anode plate 203d/an anode plate 203e/a cathode plate 202e/empty space/an anode plate 203f/empty space. Successively folded along the folding line 204, a stacked body shown in FIGs. 3 and 4 is obtained in which each of the cathode plates 202 is alternating with each of the anode plates 203, and the taps of the cathode plates 202 and the anode plates 203 overlap each independently. The obtained stacked body is then housed within a suitable package, followed by injection of an electrolyte solution and packaging to produce the battery according to the present invention. The method has an advantage that the battery can be produced in a simple procedure.

FIG. 2b shows another preferred arrangement of the cathode plates 202 and the anode plates 203, in which they are arranged in a order of an anode plate 203a/empty space/a cathode plate 202a/ a cathode plate 202b/an anode plate 203b/an anode plate 203c/.../a cathode plate 202c/a cathode plate 202d/an anode plate 203d/an anode plate 203e/empty space. Successively folded along the folding lines 204, such an arrangement gives an electrode structure similar with that of FIG. 3, in which each of the cathode plates 202 and each of the anode plates 203 are alternating each other. FIG. 2c shows further another arrangement of the cathode plates 202 and the anode plates 203, in which they are arranged in a order of an anode plate 203a/empty space/a cathode plate 202a/a cathode plate 202b/an anode plate 203b/an anode plate 203c/.../empty space/empty space/.../a cathode plate 202c/a cathode plate 202d/an anode plate 203d/an anode plate 203e/empty space/a cathode plate 202e. Successively folded along the folding lines 204 at both-direction, a stacked body, in which the configuration of the separator is



, is obtained.

Therefore, it should be understood that the arrangement of the anode plates and the cathode plates are not particularly limited, provided that both the cathode plates and the anode

plates are adhered onto one surface of the separator and that a stacked body, in which each of the cathode plates and each of the anode plates are alternating each other and connected in parallel, the taps of the cathode plates and the anode plates overlap each independently, and the alternating cathode and anode plates are separated by the separator, is obtained.

The number of the anode plates or the cathode plates can be suitably selected, regarding the anode active material to be used, the cathode active material to be used, the electrolyte to be used, and the desired discharge capacity of the battery. When the number of the anode plate (or the cathode plate) is more than 100, the folding process may be complicated. Therefore, the anode plate is used in a range of 1-100. Preferably, 1-50, more preferably, 2-20, most preferably 4-15 anode plates are used.

Detailed illustration is as follows. Lithium-transition metal oxides as a cathode active material, optionally in combination with a current conductive material, a binder and additives such as an antioxidant and a flame retardant, was dispersed into a suitable solvent and then coated onto a cathode current collector (for example, an aluminum thin plate). The coated cathode current collector was dried, pressed with a roll presser, and then cut into a suitable size to give a cathode plate. Likewise, an anode active material and a binder was dispersed into a suitable solvent, coated, dried, pressed and then cut into a suitable size to produce an anode plate. As shown in FIGs. 2a to 2c, the obtained cathode and anode plates were arranged in a predetermined order onto one side of a separator onto which an ion-conductive polymer material had been coated. Successive folding of the electrode plates-arranged separator produces a stacked body in which each of the cathode plates and each of the anode plates are alternating each other, the taps of the cathode plates and the anode plates overlap each independently to connect the cathode plates and the anode plates in parallel, and the alternating cathode and

anode plates are separated by the separator. Then, the stacked body is housed within a package and then an electrolyte solution is injected to disperse and charge between the cathode plate and the separator as well as between the anode plate and the separator.

The steps of the method according to the present invention can be continuously performed to produce a lithium secondary battery in a large scale. For example, the steps a) to d) can be continuously performed after a rolled separator has been rolled out in a suitable speed. In doing so, because the electrode plates are adhered onto only one side of the separator, the adhesion process (step b) is simplified and yield is enhanced. Further, the separator onto which the electrode plates are arranged is folded in a fixed direction, rather than in zig-zag fashion such that the folding process (step c) is simplified. In a meanwhile, cutting of one end of the unrolled separator can be performed in regard to the operation condition. That is, cutting of one end of the unrolled separator can be performed between step a) and step b), between step b) and step c) or between step c) and step d).

The taps of the cathode and anode plates are led out each independently to a suitable lead such as aluminum and nickel lead, and connected in parallel by an ultrasonic welding. And then, a final battery is produced by housing the stacked body into a pouch of the package, followed by injection of the electrolyte solution and heat-sealing of the package under vacuum. At this time, iron or aluminum is in general used as a packaging material.

The present invention will be more fully described referring to specific Examples. However, it should be understood that the Examples are suggested only for illustration and should not be construed to limit the present invention. Numerous modifications could be made without departing from the scope and the spirit of the invention.

Examples

Example 1: Preparation of an electrode plate

A cathode plate was prepared by the conventional process: a mixture of 100 g of LiCoO_2 powder as a cathode active material, 5g of carbon black as a current conductive material and 5g of polyvinylidene fluoride as a binder was homogeneously mixed, and then 100ml of N-methylpyrrolidone was added to the mixture. The obtained solution was coated onto both sides of a aluminum foil having a thickness of 15 μm which serves as a current collector, dried and then pressed with a roll presser. The thickness of the cathode plate was 150 μm .

Likewise, an anode plate was prepared: 100g of graphite powder and 10g of polyvinylidene fluoride as binder was homogeneously mixed, and then 100ml of N-methylpyrrolidone was added to the mixture. The obtained solution was coated onto both sides of a copper foil having a thickness of 15 μm which serves as an anode collector, dried and then pressed with a roll presser. The thickness of the cathode plate was 150 μm .

The cathode and anode plates were cut with a puncher such that the cathode and anode plates as shown in FIG. 1 in which each of the cathode and anode plates has a tap were obtained. The cathode plates and the anode plates obtained were stored into a cassette.

Example 2: Preparation of a battery (1)

A polymer solution was prepared by mixing acetonitrile (available from Aldrich) and polyethylene oxide (available from Aldrich, average molecular weight 1,000,000) at a ratio of 100:3 by weight. The obtained polymer solution was coated onto one side of a porous polyethylene sheet (TecklonTM manufactured by ENTEK, thickness: 25 μm) which serves as a separator with a liquid constant delivery apparatus in a thickness of 2 μm .

The five cathode plates and the six anode plates from the cassette were arranged in an

order as shown in FIG 2a, onto one side of the separator onto which the polymer solution was coated and then successively folded along the folding line, thereby forming a stacked body as shown in FIG. 3. The projected taps of the cathode plates and the anode plates were led out by nickel and aluminum leads and welded in parallel with an ultrasonic wave, each independently. The stacked body was housed within an aluminum laminating sheet having a pouch to house the stacked body, and an electrolyte solution prepared by dissolving by 1.2mol of LiPF_6 into 3 ml of a mixed solvent of ethylene carbonate and ethylmethyl carbonate (1:1, by volume) was injected into the pouch. Heat-sealing of the pouch under vacuum produced a lithium secondary battery having a thickness of 38 mm, width of 35 mm and length of 62 mm.

Example 3: Preparation of battery (2)

A lithium ion secondary battery was prepared in the same manner as described in Example 1 except that polymethyl methacrylate was used instead of polyethylene oxide.

Comparative Example 1

The lithium secondary battery described in KR 309,604 was prepared in the same as described in Example 2 except that five cathode plates were adhered to one side of the separator in a predetermined order onto which a polyethylene oxide solution was coated. Then, the polyethylene oxide solution was further coated onto the other side of the separator and five anode plates were adhered to the other side of the separator such that an arrangement in which the separator are sandwiched between the cathode plates and the anode plates was obtained. Folding was performed in zig-zag fashion to produce the battery.




Test of Cycle life of batteries

Cycle life of the battery of Example 2 was tested and compared with that of

Comparative Example 1. The results thereof are shown in FIG. 5. As shown in FIG. 5, the lithium secondary battery of the present invention retained 95% or more discharge capacity after more than 40 cycles, while the battery of Comparative Example 1 had a discharge capacity of less than 90%. From these results, it was found that the battery according to the present invention had much more improved cycle life characteristics than that of Comparative Example 1.

As described above, the method according to the present invention does not require a lamination process to tightly bond an electrode membrane to a separator with high temperature and high pressure. In addition, it can provide various shapes of battery with ease and occurs no damage to the electrode plate, because each of the electrode plates is used in a pre-cut form. Compared with the lithium secondary battery disclosed in KR 309,604, the method according to the present invention can simplify the folding process and the adhesion process, because the electrode plates are adhered onto only one side of the separator and successive folding is performed in a fixed direction, rather than in zig-zag fashion. For these reasons, the method according to the present invention is adequate for applying to a continuous production of the lithium secondary battery, which enables to produce the lithium secondary battery in high yield and with an enhanced productivity. The lithium secondary battery produced has advantages that each of the cathode plates and each of the anode plates are stably separated by the separator tightly retained in the battery such that cycle life characteristics are improved.

CLAIMS

1. A lithium secondary battery comprising a plurality of cathode plates and a plurality of anode plates in which each of the cathode and anode plates has a tap, a separator on which a ion-conductive polymer material is coated on one side of the separator and an electrolyte, wherein each of the cathode plates and each of the anode plates are alternating each other and connected in parallel, the taps of the cathode plates and the anode plates overlap each independently, the alternating cathode and anode plates are separated by the separator having a structure of ,  or , and the electrolyte is charged between each of the cathodes and each of the anodes separated by the separator.

2. The lithium secondary battery of claim 1, wherein the cathode or anode plate is a member in which a cathode or anode active material is coated onto either one or both sides of a current collector.

3. The lithium secondary battery of claim 2, wherein the cathode active material is a lithium transition metal oxide.

4. The lithium secondary battery of claim 2, wherein the anode active material is selected from the group consisting of metallic lithium, lithium alloy, carbon and graphite.

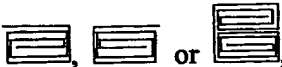
5. The lithium secondary battery of claim 1, wherein the ion-conductive polymer material is selected from the group consisting of polypropylene oxide, polyurethane, polymethylmethacrylate, polybutylmethacrylate, polycyanoacrylate, polyethylene acrylic acid, polyacrylonitrile, polyvinylidene fluoride, polyhexapropylene fluoride, polyethylene oxide, and

mixture thereof.

6. The lithium secondary battery of claim 1, wherein the separator is selected from the group consisting of a polyethylene film, a polypropylene film, a polyvinylidene fluoride film, a hexapropylene fluoride film, a polyethylene oxide film and a combination thereof.

7. The lithium secondary battery of claim 1, wherein the electrolyte is selected from the group consisting of liquid electrolyte, gel electrolyte and solid electrolyte.

8. A method for fabricating a lithium secondary battery of claim 1, comprising:

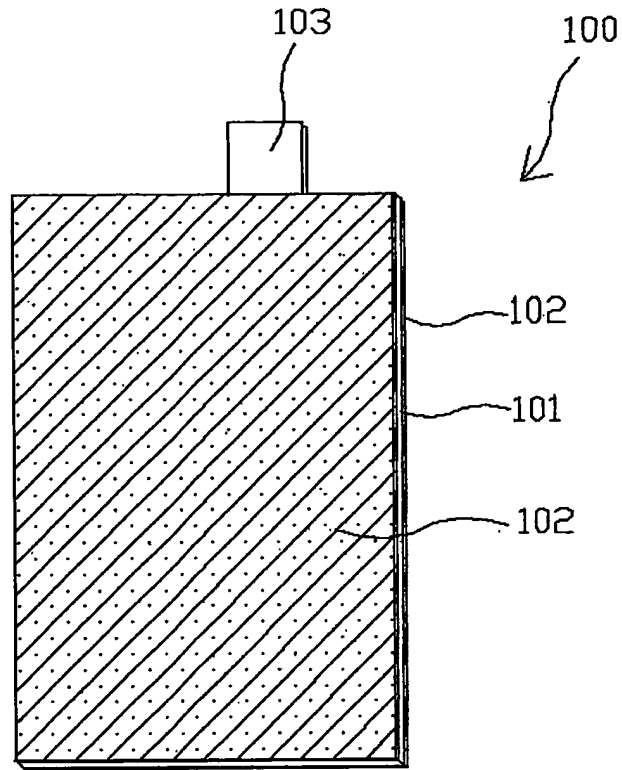
- a) coating one side of a separator with an ion-conductive polymer material;
- b) arranging a plurality of cathode plates and anode plates in a predetermined order onto the surface of the separator on which the ion conductive polymer material is coated such that a stacked body, in which each of the cathode plates and each of the anode plates are alternating each other and connected in parallel, the taps of the cathode plates and the anode plates overlap each independently, and the alternating cathode and anode plates are separated by the separator having a structure of , is prepared by a successive folding;
- c) performing a successive folding of the separator to obtain the stacked body; and,
- d) housing the obtained stacked body within a package, followed by injection of an electrolyte solution and packaging.

9. The method of claim 8, wherein the step b) is carried out by positioning one anode or cathode plate at an end of the separator, and two adjacent cathode plates and two adjacent plates are arranged at a middle of the separator, and empty spaces are suitably formed between the cathode plate and the anode plate.

10. The method of claim 8, wherein the electrolyte solution contains a lithium salt.
11. The method of claim 8, wherein the steps a) to d) are continuously carried out.

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FIG. 1



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FIG. 2a

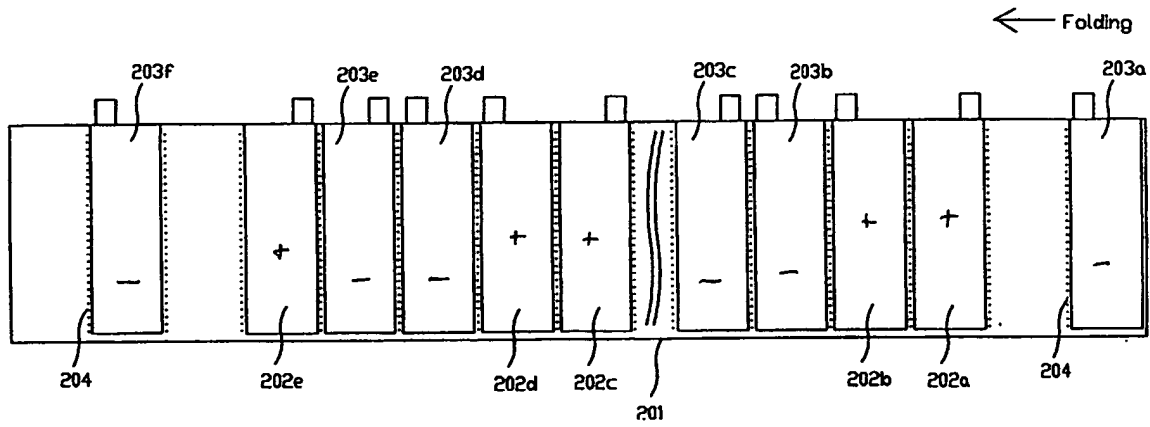
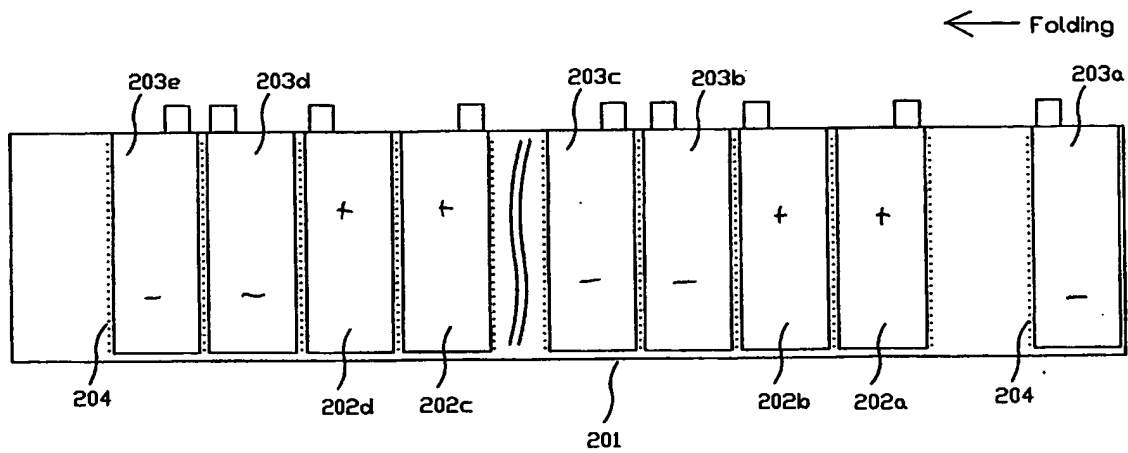


FIG. 2b



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FIG. 2c

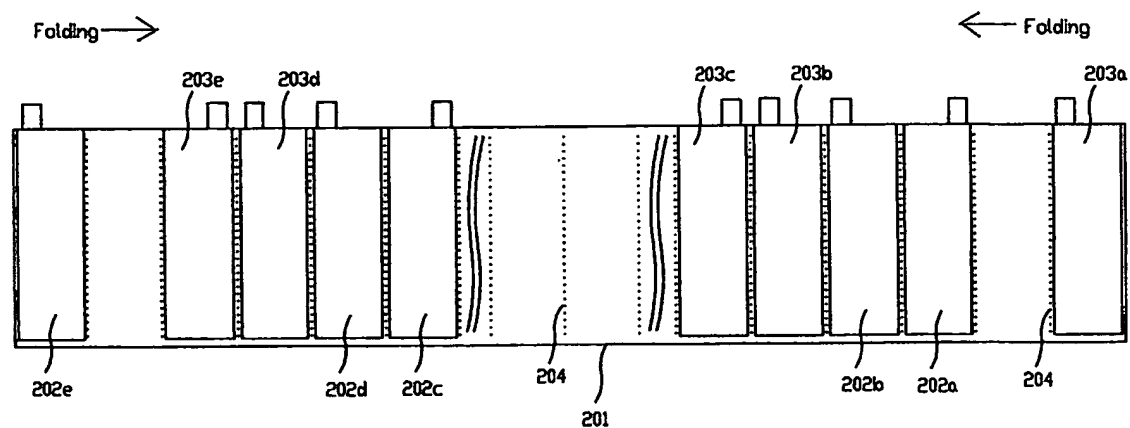
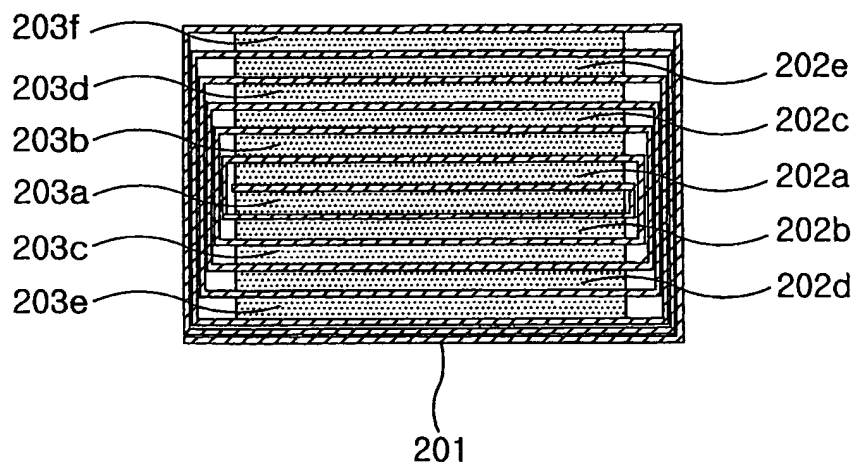


FIG. 3



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FIG. 4

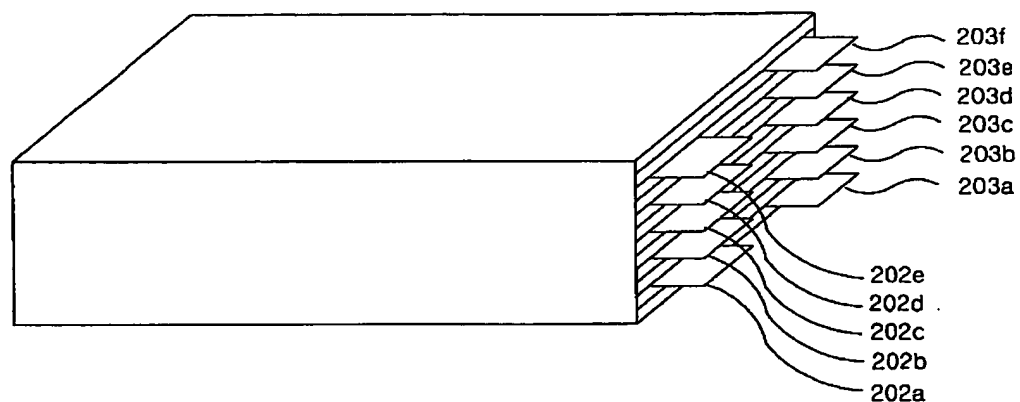
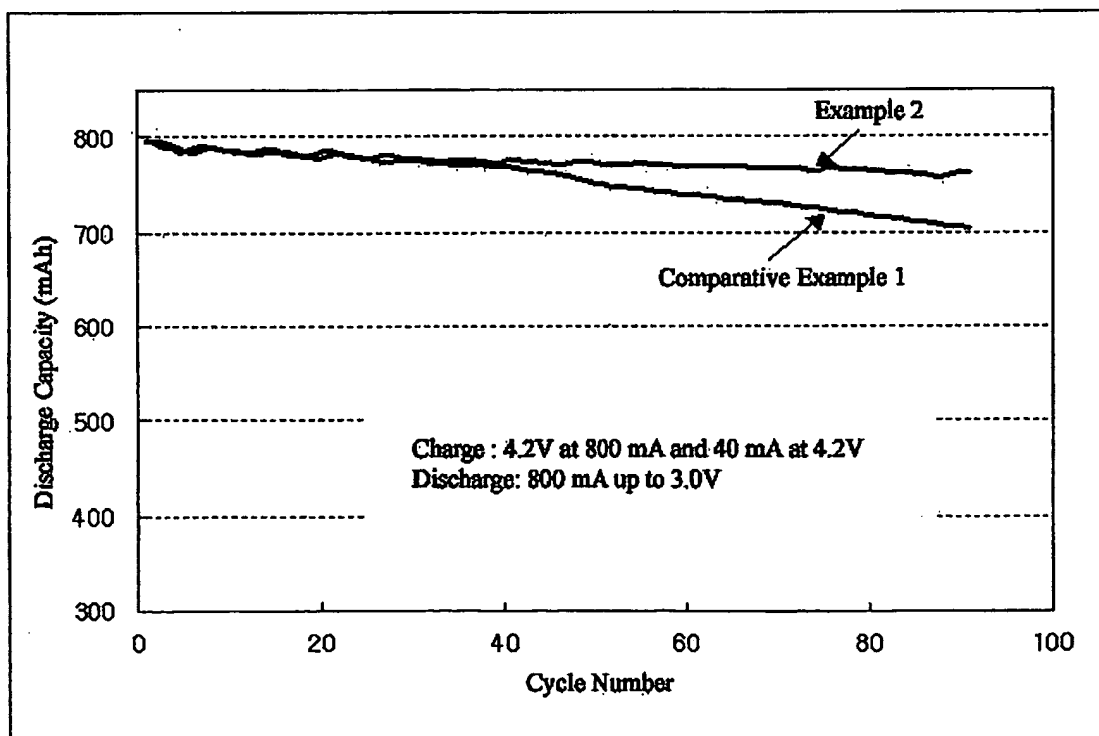


FIG. 5



INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR03/01012

A. CLASSIFICATION OF SUBJECT MATTER**IPC7 H01M 10/38**

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7 H01M 10/38, H01M 10/40

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Patents and applications for inventions since 1975

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 2001-61 A (Kokam Engineering Co.,Ltd.) 05 January 2001	1, 6-7, 8-11
X	JP 11-40201 A (Nippon Electric Co.,Ltd.) 12 February 1998	2-4
A	US 5582931 A (Canon Kabushiki Kaisha) 10 December 1996	1-11
A	US 5156932 A (Globe-Union, Inc) 20 October 1992	1-11
A	US 6232014 A (Mitsubishi Denki Kabushiki Kaisha) 15 May 2001	1-11
A	US 6242128 A (Valence Technology, Inc) 05 June 2001	1-11
A	JP 07-057716 A (Sony Corp) 03 March 1995	1-11
A	WO 9939397 A (Chemieco) 05 August 1999	1-11
E, X	US 6423449 A (Kokam Engineering Co.,Ltd.) 23 July 2002	1, 6-7, 8-11

☐ Further documents are listed in the continuation of Box C.☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

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"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search

26 JUNE 2003 (26.06.2003)

Date of mailing of the international search report

27 JUNE 2003 (27.06.2003)

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